Makai Ocean Engineering, Inc.

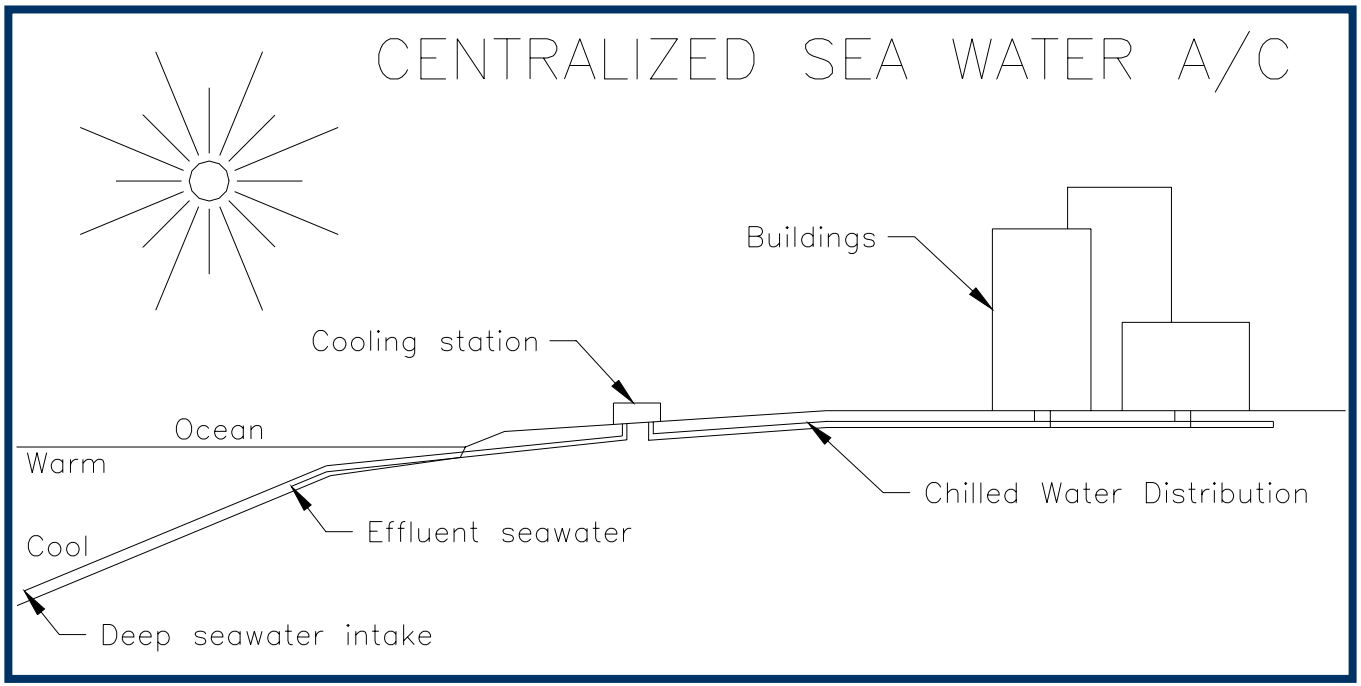
Seawater Air-Conditioning & Deep, Cold Water Pipeline Experience

Outline of Presentation:

- What is Seawater Air Conditioning?
- Seawater AC Technology.
- Deep Water Pipelines – major cost and risk
- Why are we interested in SWAC?
- Where is it being used?
- Can it be applied in Hawaii?

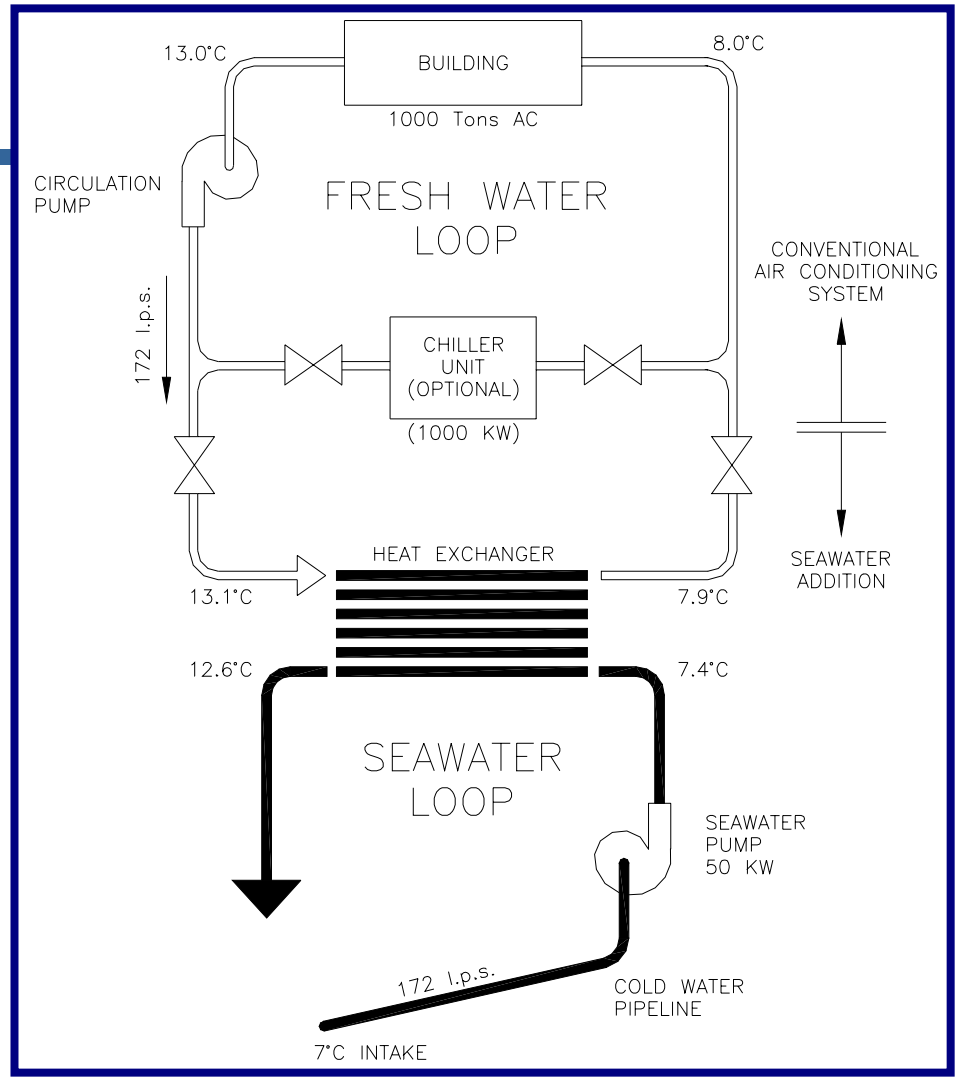
Basic SWAC Components:

- Pipe
- Pump Station
- Heat Exchanger
- Distribution



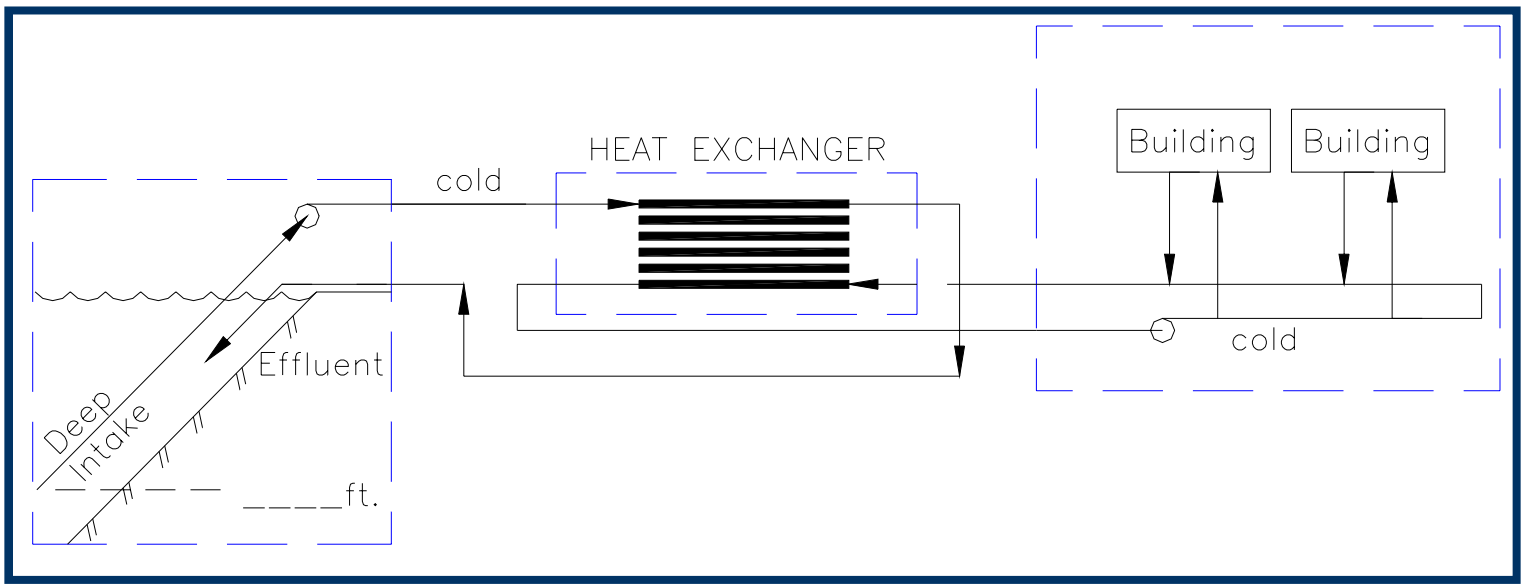
Schematic:

- Cooling source Transparent to the User
- Same Temperatures
- No seawater at user
- Simple Substitution



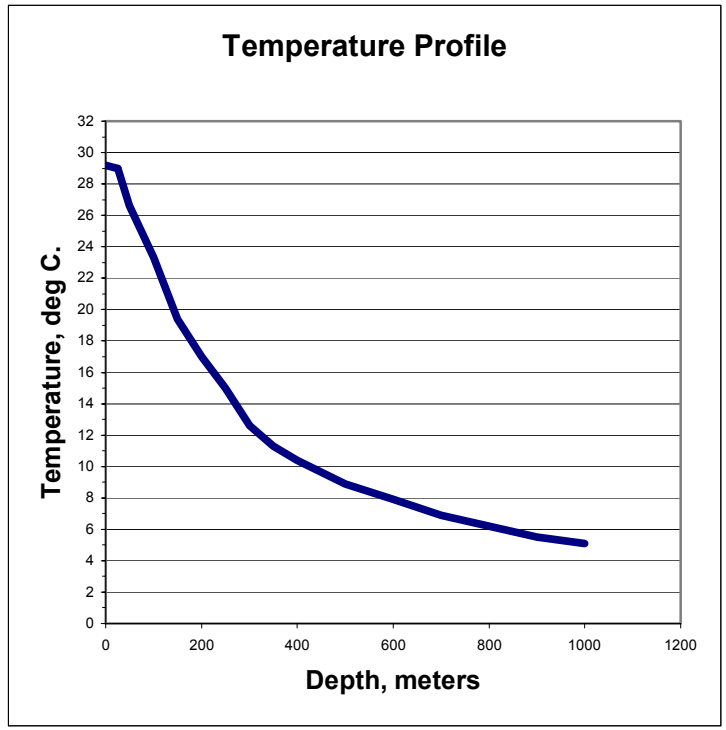
Typical Arrangement

- Seawater and fresh water isolated
- Fresh chilled water adequate temperature



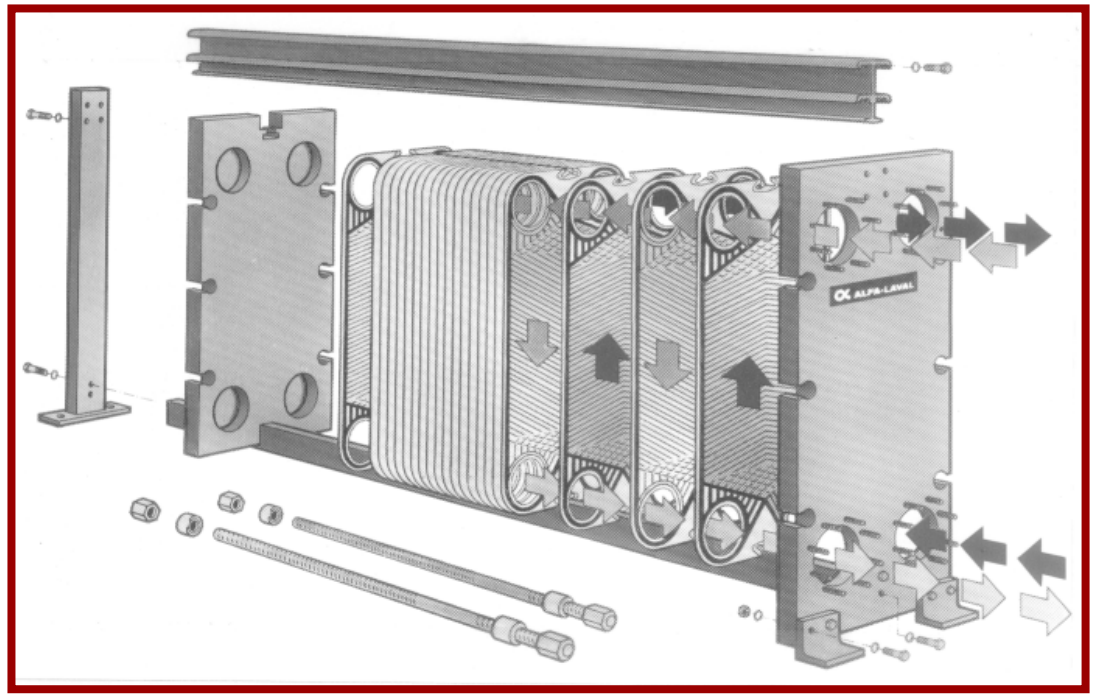
Access to Cold Water

- Most oceans
  - 42-3 deg F at 2000’
- Lakes in N climates
  - 39-40 deg F at 300’
- Infinite Heat Sink



Heat Exchangers

- Titanium
- Standard for Seawater
- No fouling – Proven at NELHA
- No corrosion



Deep Water Pipelines: Technology Developed in Hawaii

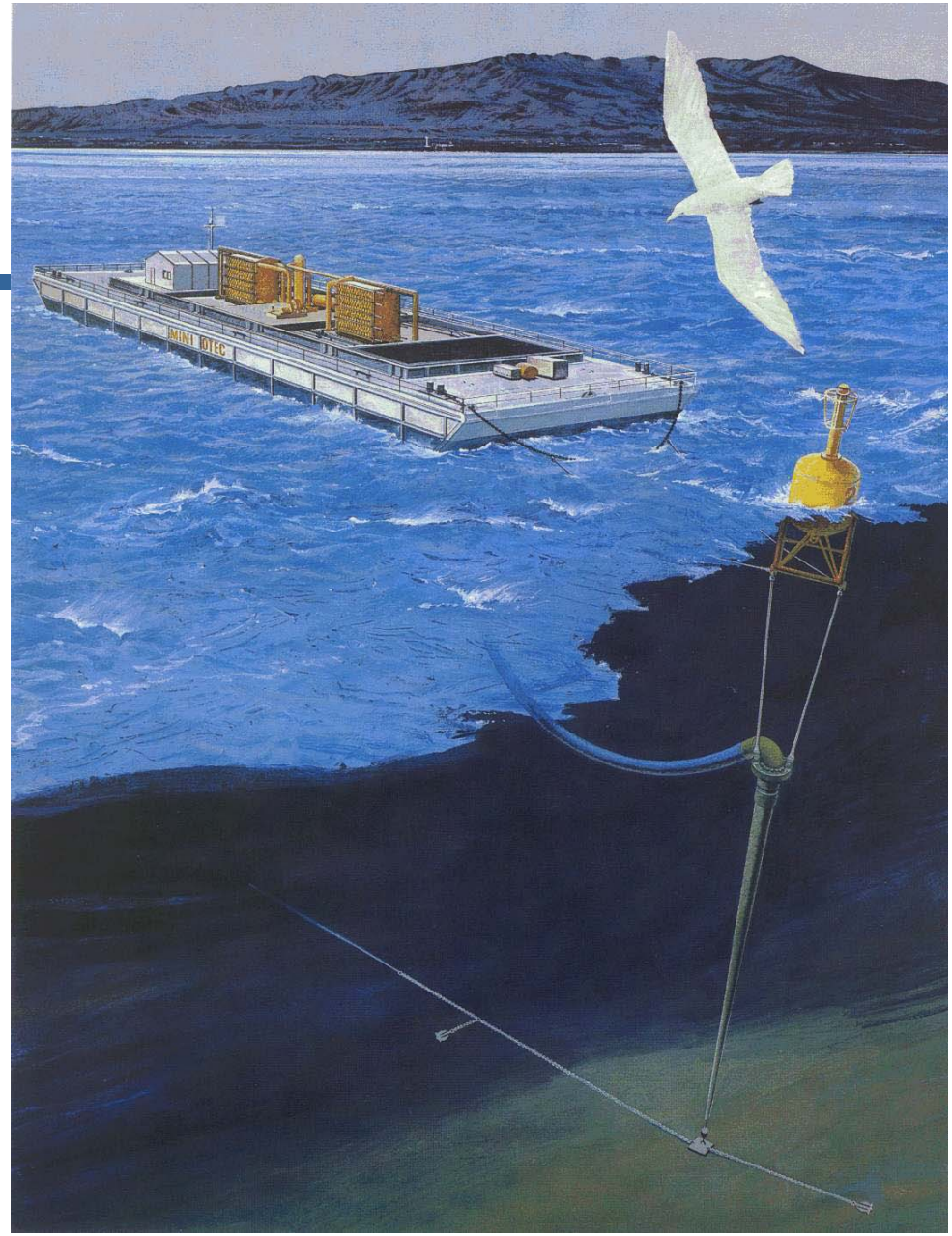
- World Recognized SWAC potential for years
- Major Unknown Technology: Deep Water Pipes
- Pipelines at NELHA have made SWAC practical
- 5 major deep water pipelines – developed in Hawaii – 1979 through 2001.

Major Pipelines by Makai

- NELHA
  - 24” Mini OTEC
  - 12” Down the Slope
  - 18” Pendant
  - 48” Pipe - lost
  - 40” Catenary
  - 55” DTS and Pendant
- Others
  - Cornell 63”
  - DOE 8’ suspended R&D
  - DOE 8’ Down the slope demo
  - 63” Toronto
  - 40” India suspended

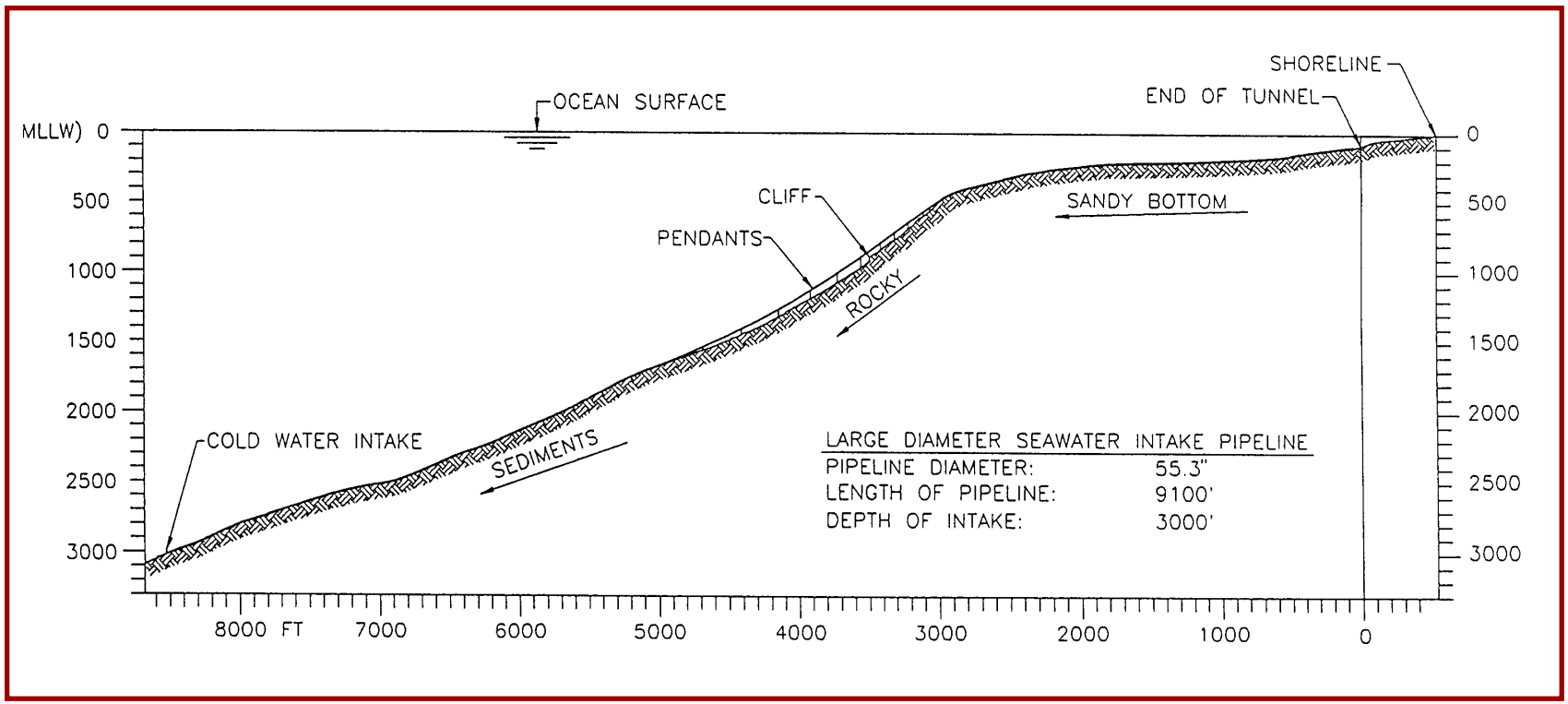
Mini OTEC

- First Hawaii deep water pipeline
- HDPE
- Flexible mooring and intake pipe



Hawaii Pipelines – Keahole Pt.

- Steep Slope
- Rough Seafloor



Pipeline Material

- HDPE
- Rugged
- Flexible
- Strong Joints
- Long Life in seawater

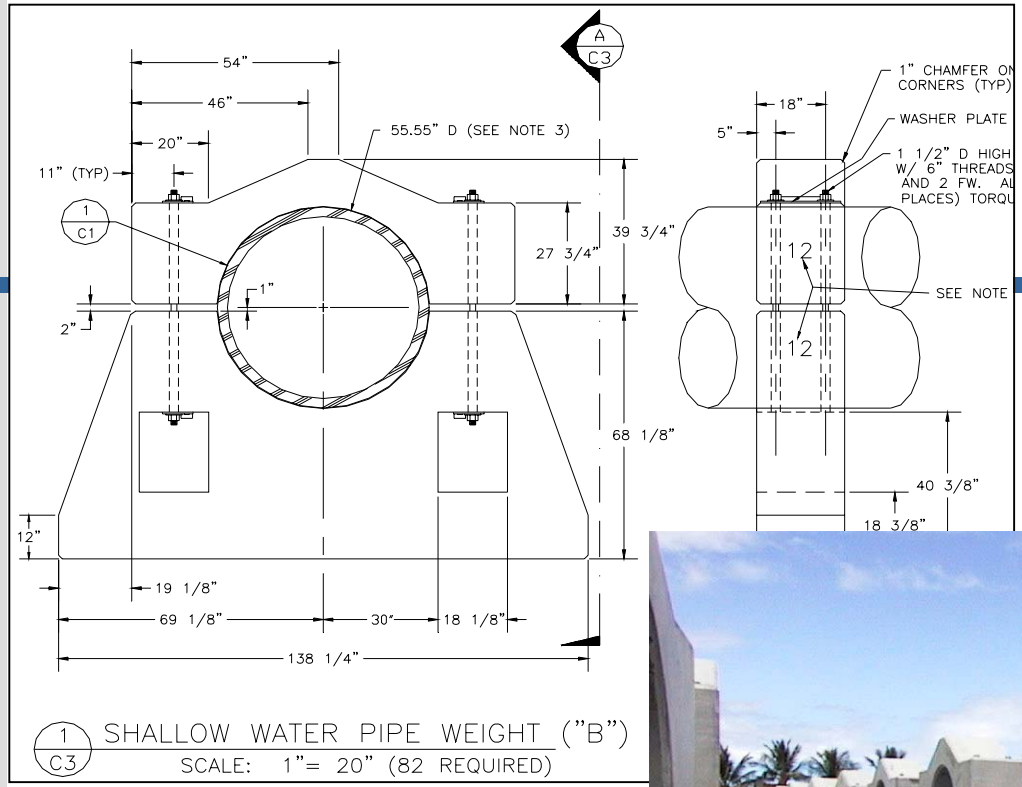
Pipeline Joints

- Heat Fused
- Strong as Pipe

CWP Launch

- Railroad
- Launch as Pipe is Fused
- Pipe Floats Air-filled

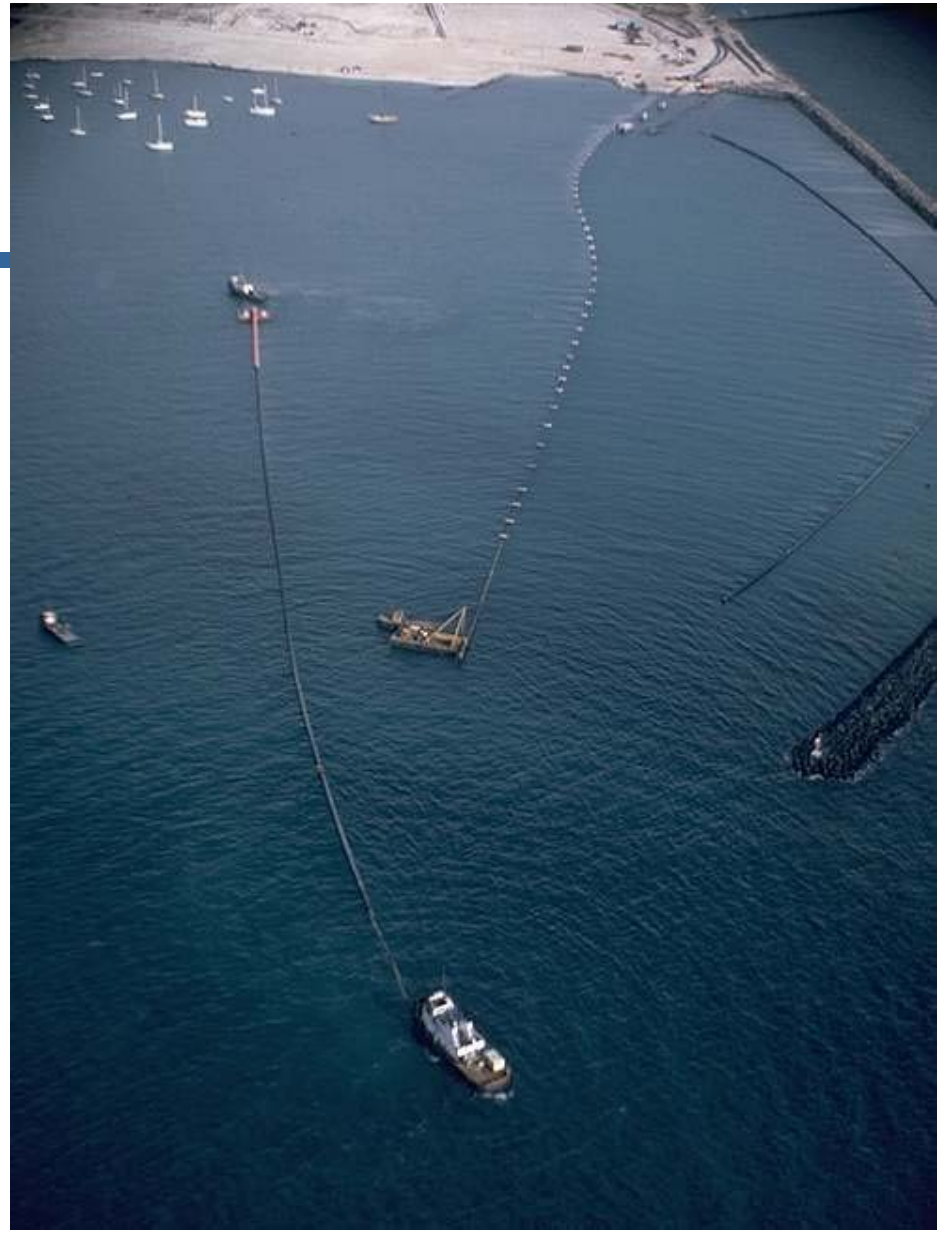
40” CWP Launch


A
C3
54"
46"
20"
11" (TYP)
55.55" D (SEE NOTE 3)
1
C1
1"
2"
27 3/4"
39 3/4"
68 1/8"
12"
19 1/8"
69 1/8"
30"
18 1/8"
138 1/4"
18"
5"
1" CHAMFER ON
CORNERS (TYP)
WASHER PLATE
1 1/2" D HIGH
W/ 6" THREADS
AND 2 FW. AL
PLACES) TORQU
12
12
SEE NOTE
40 3/8"
18 3/8"
1
C3
SHALLOW WATER PIPE WEIGHT ("B")
SCALE: 1"= 20" (82 REQUIRED)


71
72
73

Pre-Deploy

- Assemble Pipe Section in Kawaihae Harbor
- Tow to site overnight



CWP Tow

- Tow Air-Filled
- 15% to 90% buoyant
- Low pressure inside

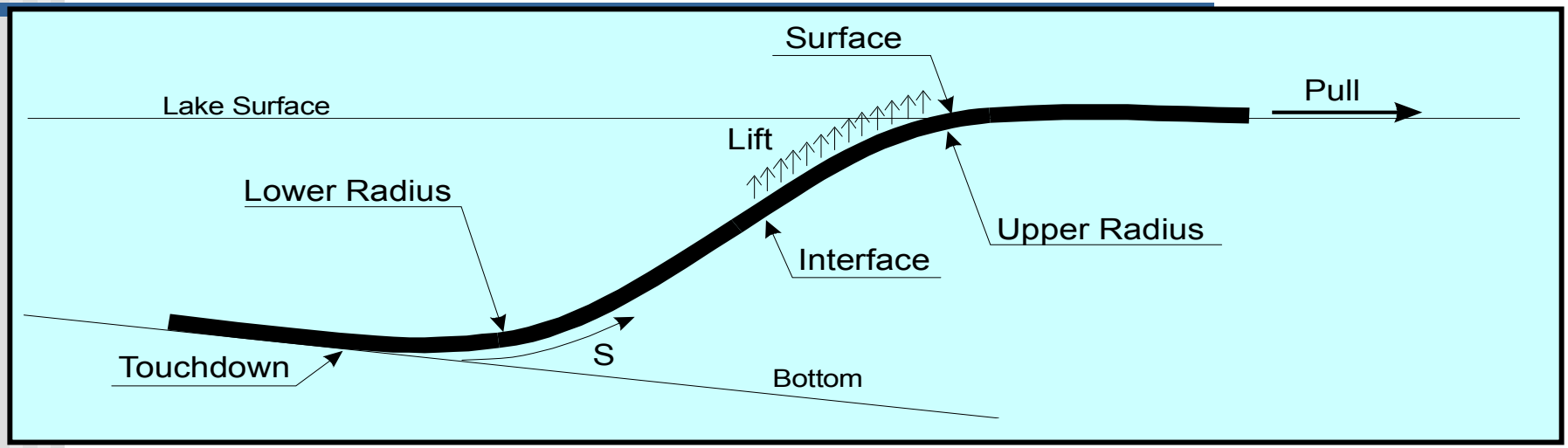
Alignment

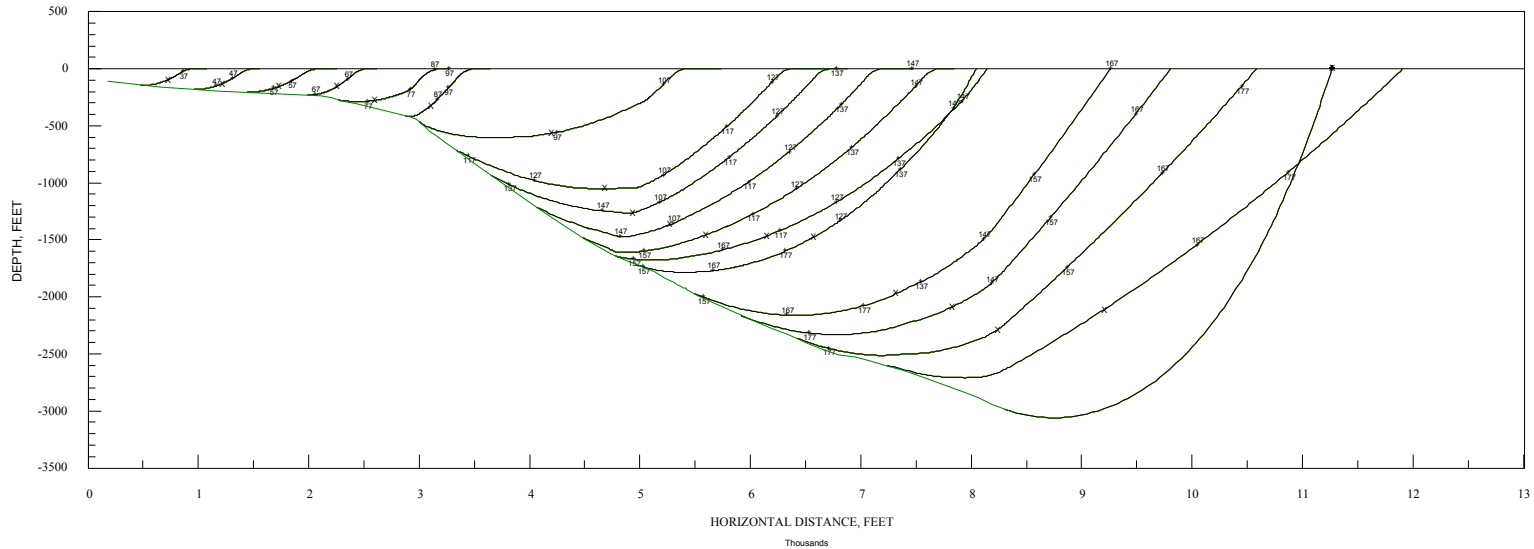
- Align over Path
- Shoreline Connection

40” CWP prior to Submergence

Controlled Submergenc

- Balance of Pipeline Properties

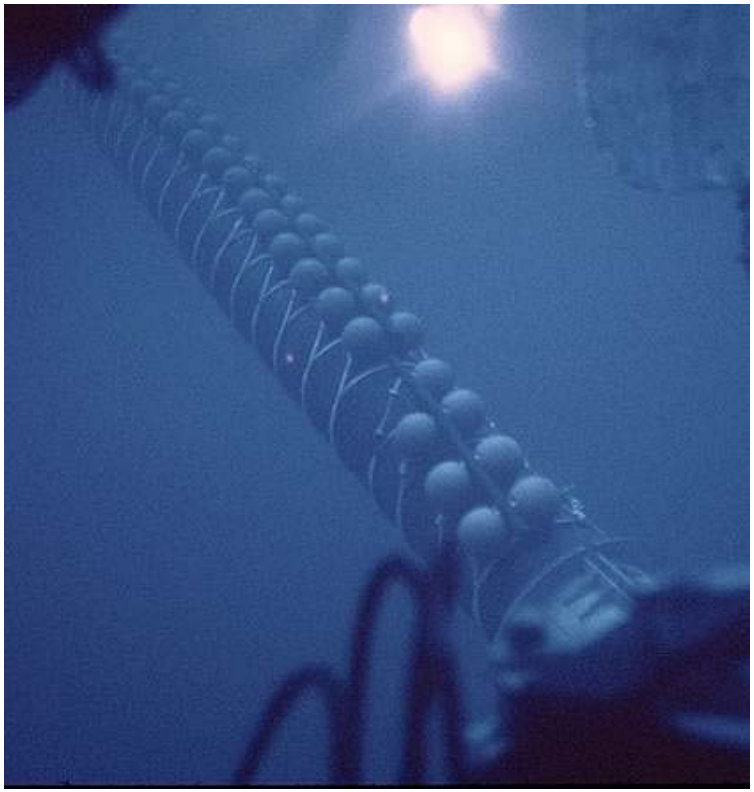





REMORA
6000


Y:316929.9 X:302449.5
10:10:32 12 OCT 2001
55" MELHA Pipe deployment

Inspection, Maintenance

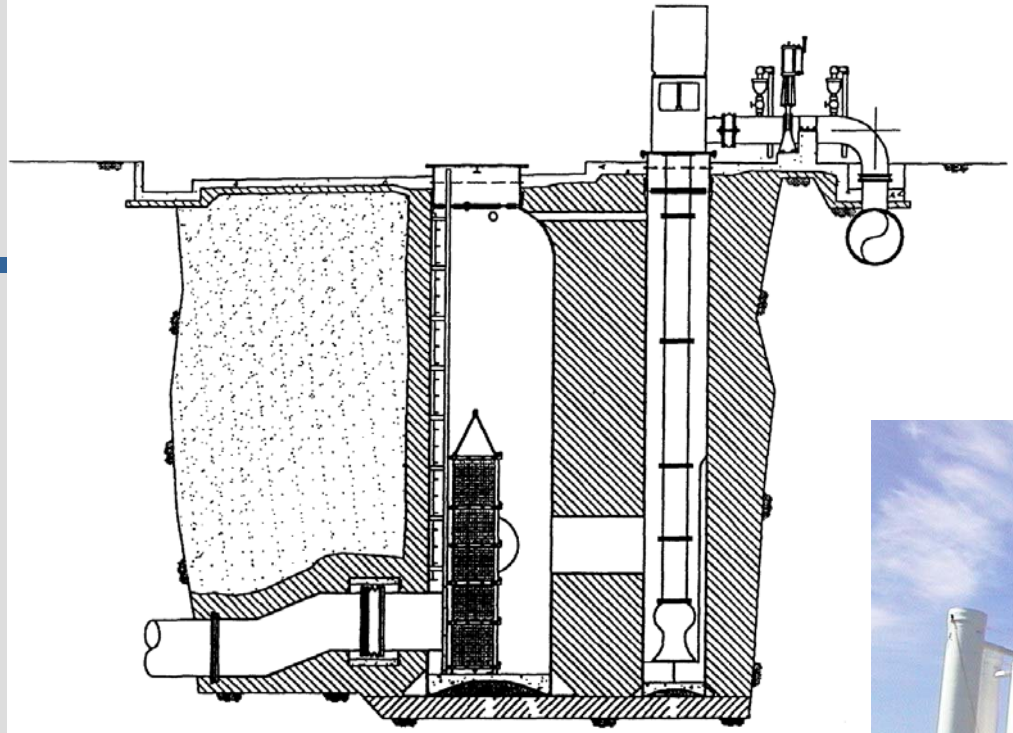


Top of Catenary

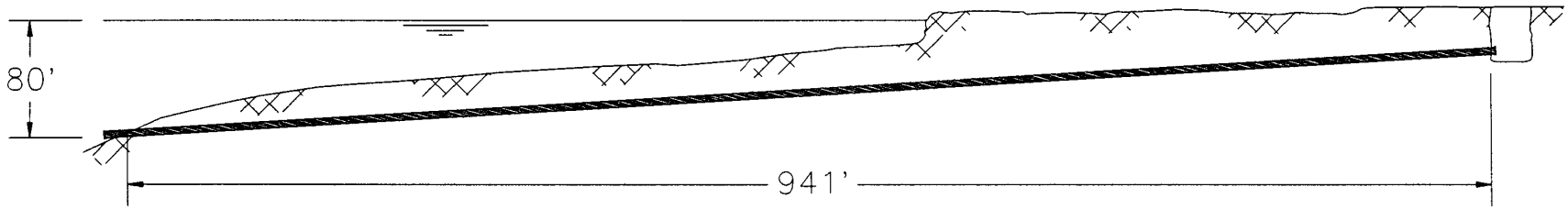
Intake

Newest NELHA Pipeline:

- 3000’ (900m) intake
- 55” diameter warm and cold water pipes
- 39° F. (4° C.) intake
- 27,000 GPM (1.7 m^3/sec) cold water flow
- Deployed September, 2001
- Suitable 17,000+ tons AC

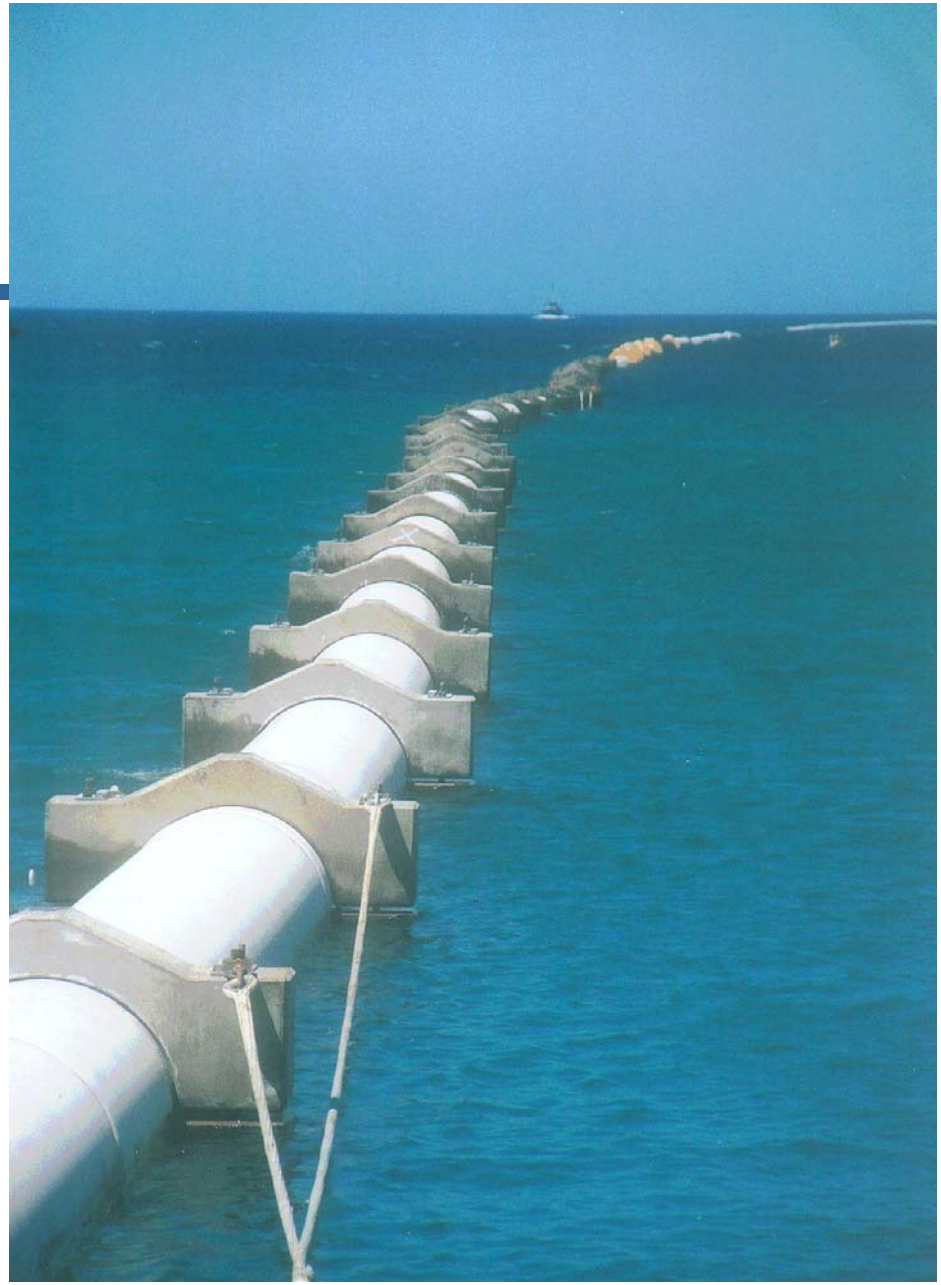


Pump Station


80’
941’

55” CWP

- Suitable for 17,000+ tons of AC
- 4 deg C water



Why SWAC?

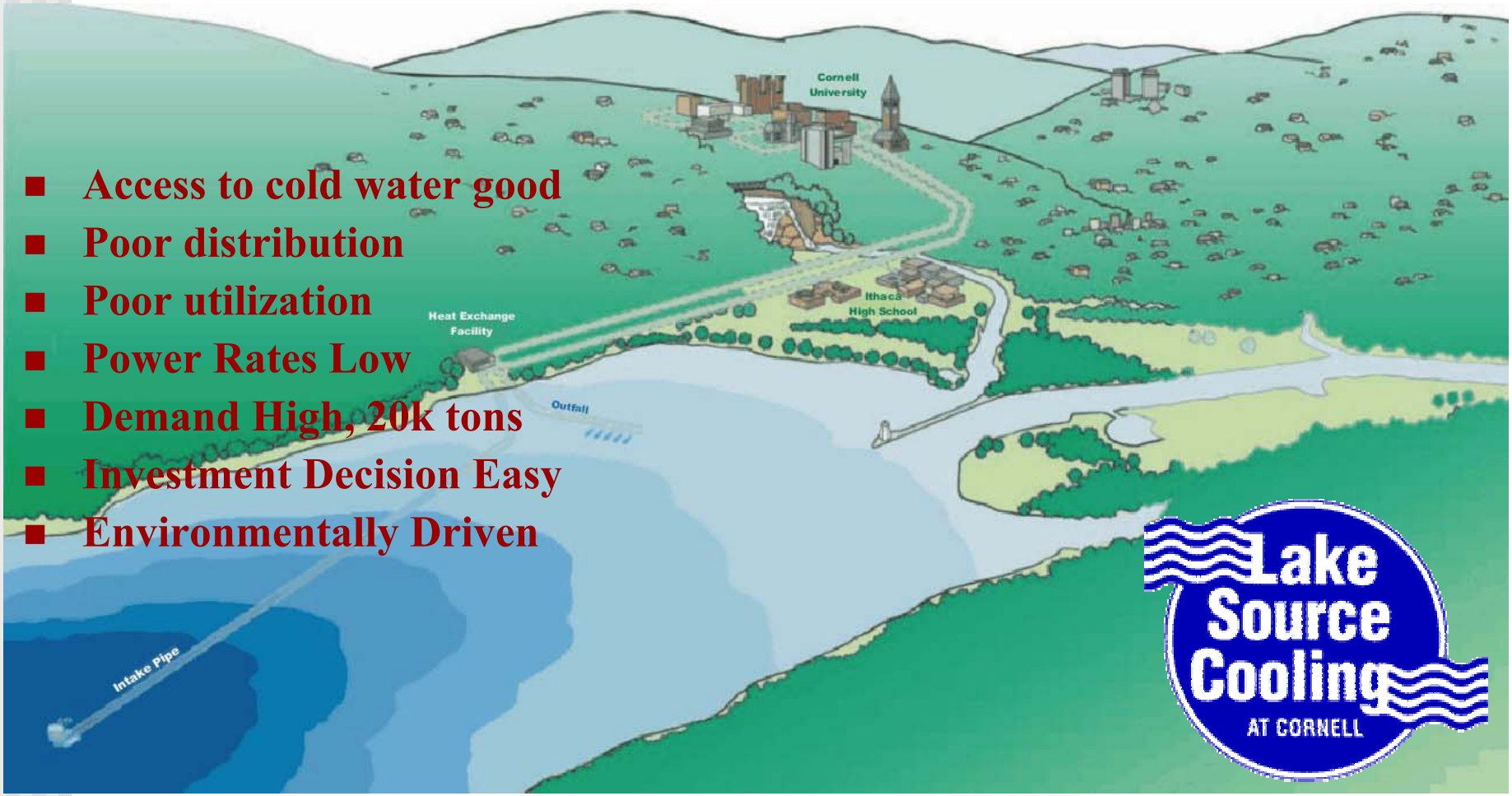
- The right solution:
  - Economically and
  - Environmentally
- Simple Technology
- 75% to 90% Energy Savings
  - Comparable reduction in emissions
- Reduce or eliminate fluorocarbons
- No global warming
- Economical today at some locations

Where is SWAC being used?

- Cornell University, Ithaca, NY: 20,000 tons
- Toronto, Canada: 58,000 tons
- New Brunswick, Nova Scotia: 1000 tons
- Sweeden, large systems
- Hawaii (NELHA) 30-50 tons
- Tahiti: 450 tons *
- Curacao: 1200 tons *
- Korea: 2000 tons *

* under development

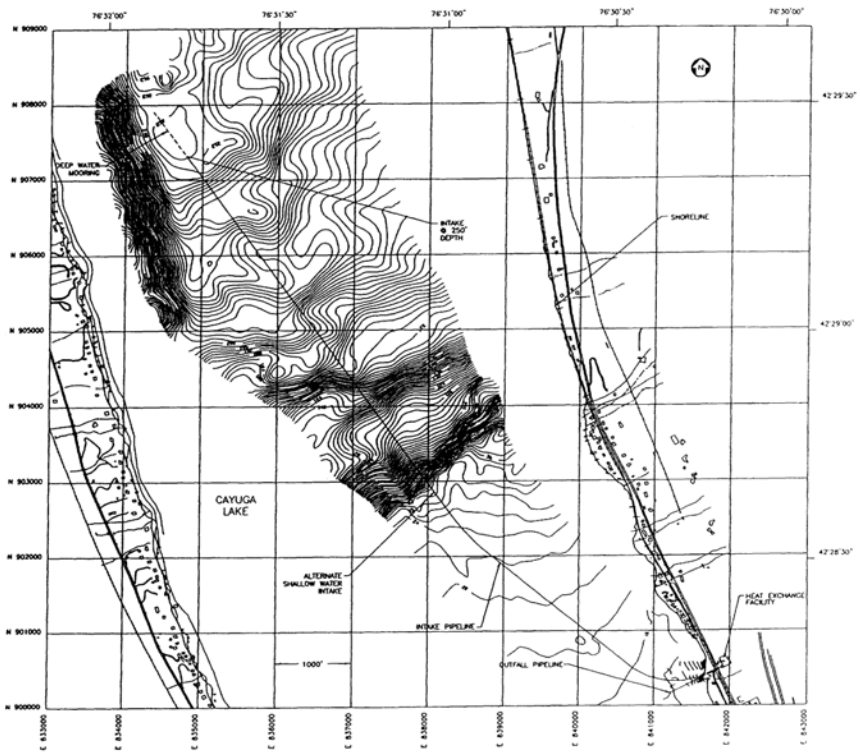
Cornell – Project



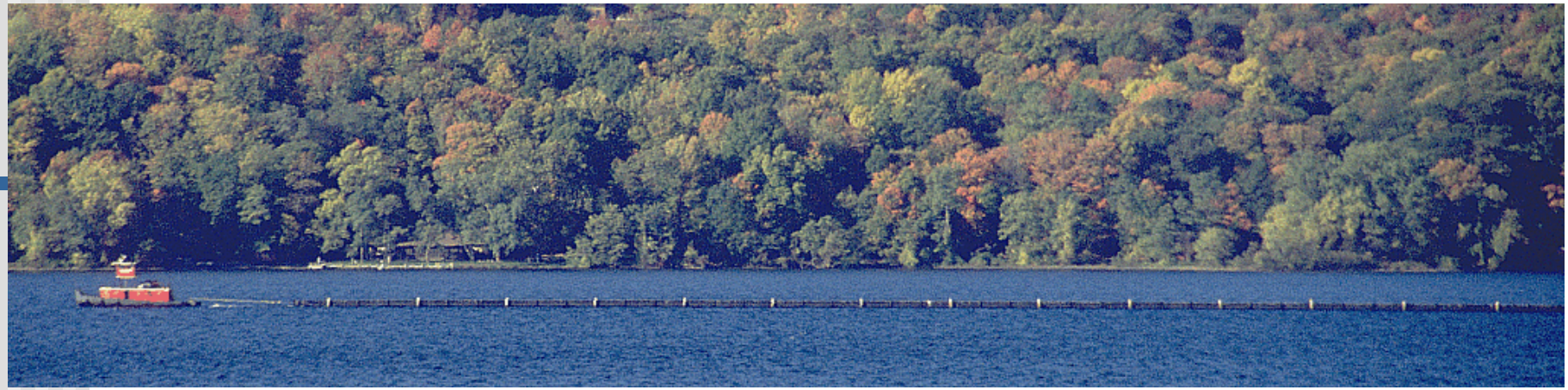
- Access to cold water good
- Poor distribution
- Poor utilization
- Power Rates Low
- Demand High, 20k tons
- Investment Decision Easy
- Environmentally Driven

Cornell – CWP

- 2mi, 63” dia pipeline
- 32,000 gpm
- 4-5 deg C.



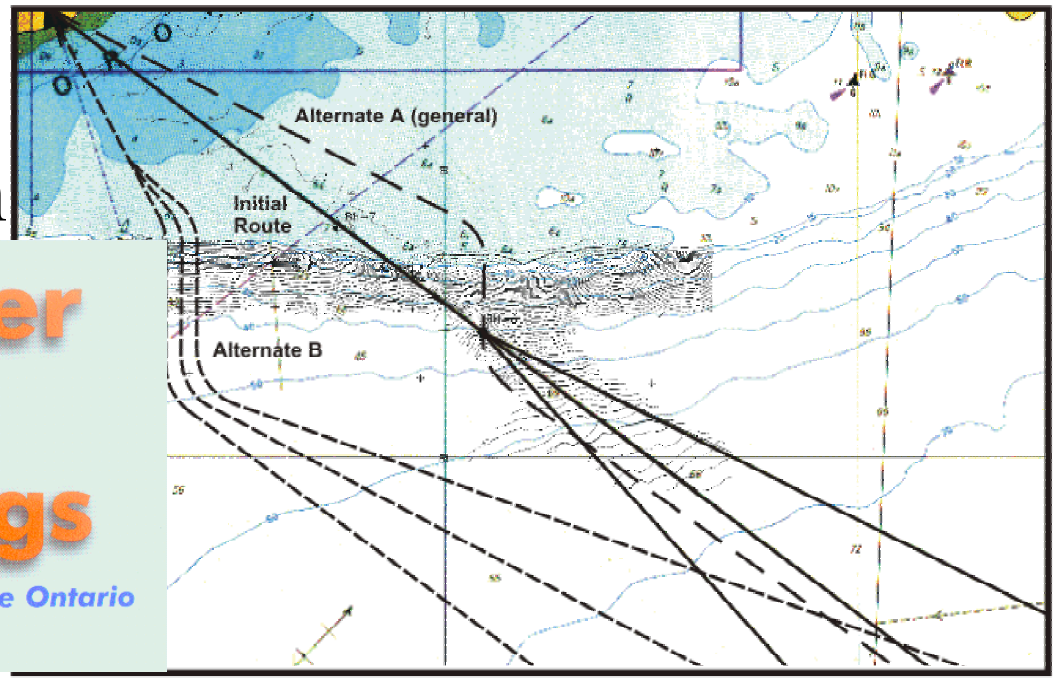
Makai Ocean Engineering, Inc.



A major lake Installation

Toronto

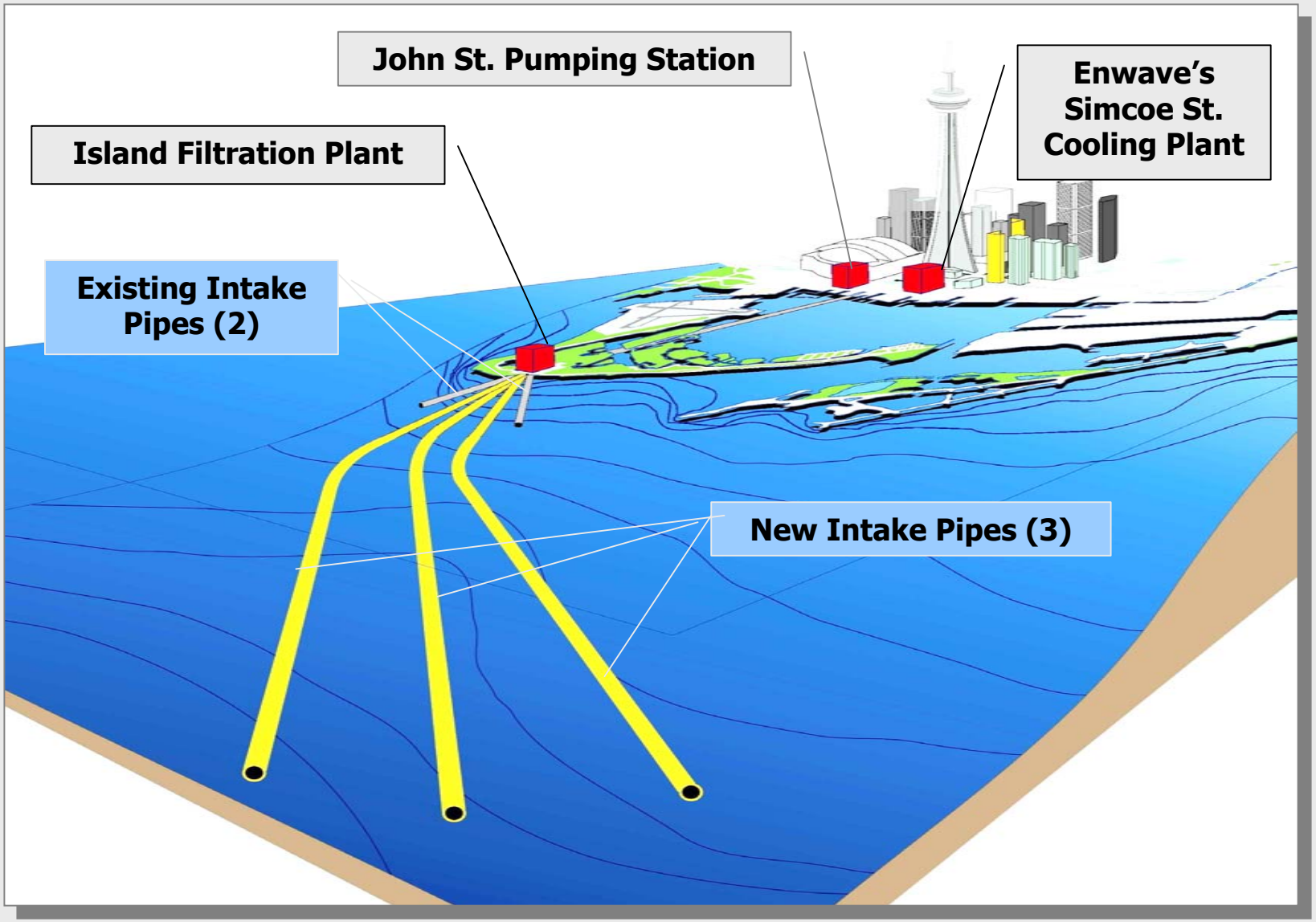
- Municipal Water + Cooling
- 3-63” Pipelines, 4 mi long each
- Lake Ontario
- In Construction



Deep Lake Water Project to Cool Toronto Buildings

Innovative proposal “borrows” coldness from Lake Ontario to replace traditional forms of air conditioning

Toronto: 58,000 tons AC

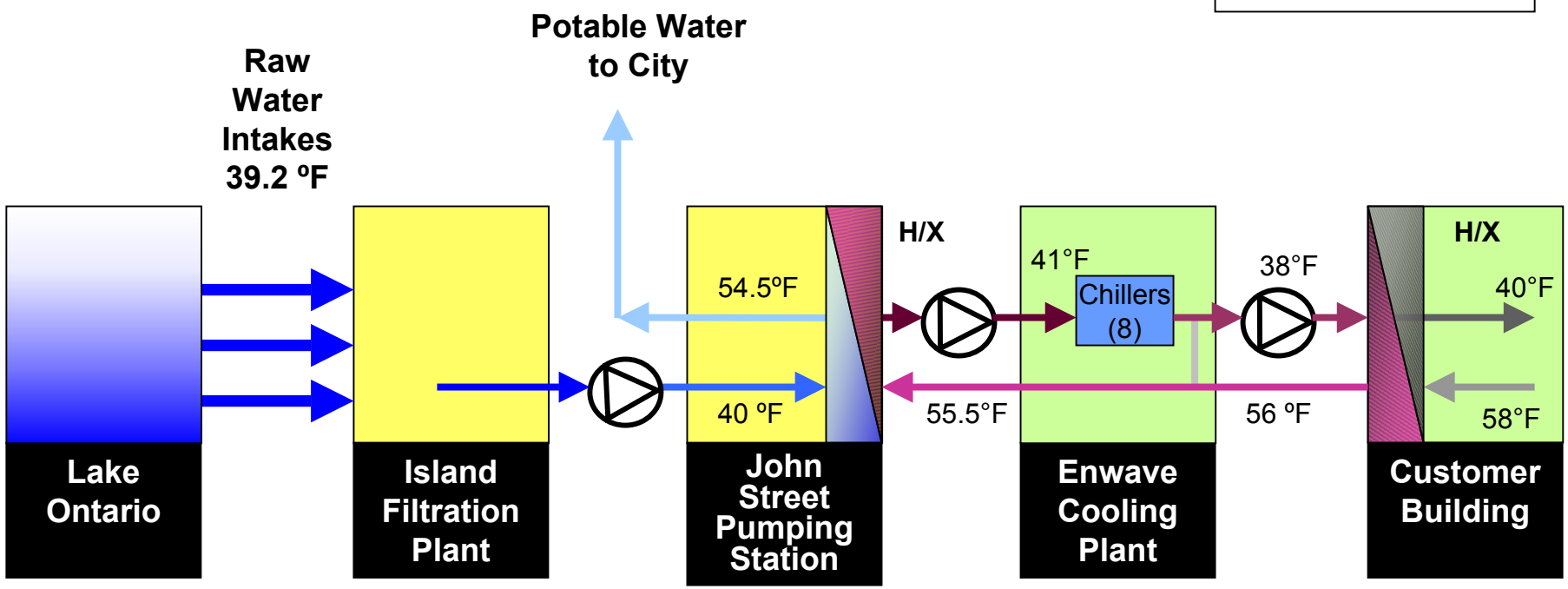


Basic Elements of Deep Lake Water Cooling

Temperature Conversion			
39.2F	= 4C	55.5F	= 13.1C
40F	= 4.44C	54.5F	= 12.5C
41F	= 5C	56F	= 13.33C
38F	= 3.33C	58F	= 14.44C

Pump

H/X = Heat Exchanger

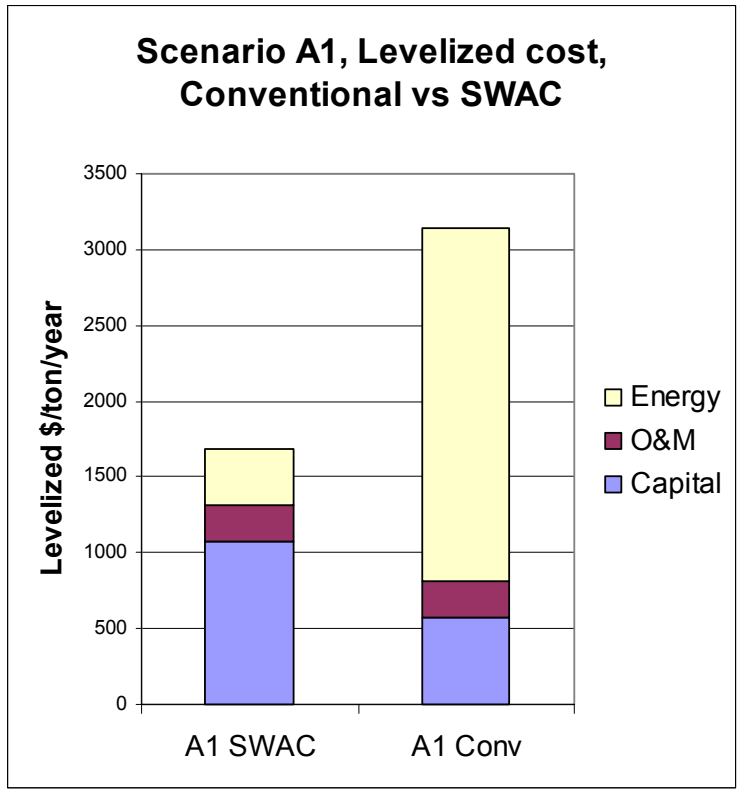


Toronto Environmental:

- Energy use is reduced by up to 75% compared with conventional chiller equipment
- DLWC cooling saves 30 million kWh/yr, enough to meet the power requirements of 4,200 homes
- 45,360 kg of refrigerants are eliminated
- CO_2, NOx and SOx emissions are reduced

Is SWAC Economical?

- SWAC has high capital, low operating costs
- Conventional has low capital, high operating costs
- SWAC prices do not escalate over lifetime
- High Capital not attractive to developers



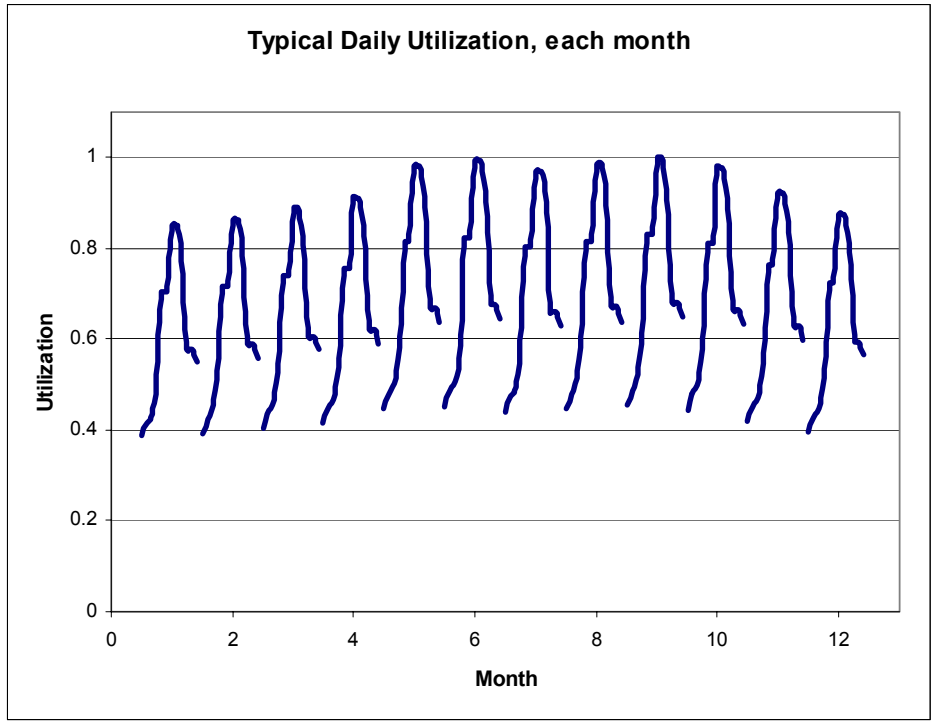
Parameters favoring SWAC:

- Good Access to deep cold water
- Customers close to shore, small distribution
- High Utilization throughout the year
- Large Size
- High Electrical Rates

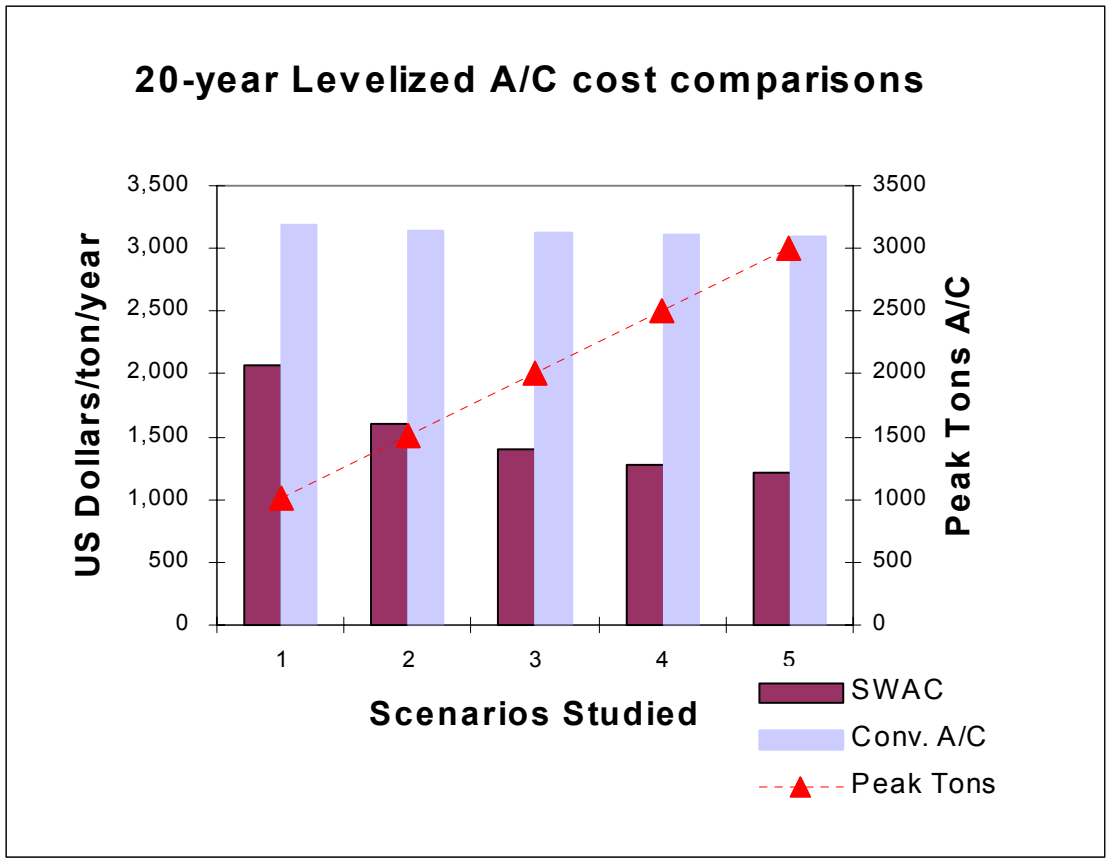
Not all have to be favorable

Utilization

- Major SWAC cost is capital
- Operating costs are low
- This favors maximum use
- Hi better than Cornell or Toronto



Impact of Size

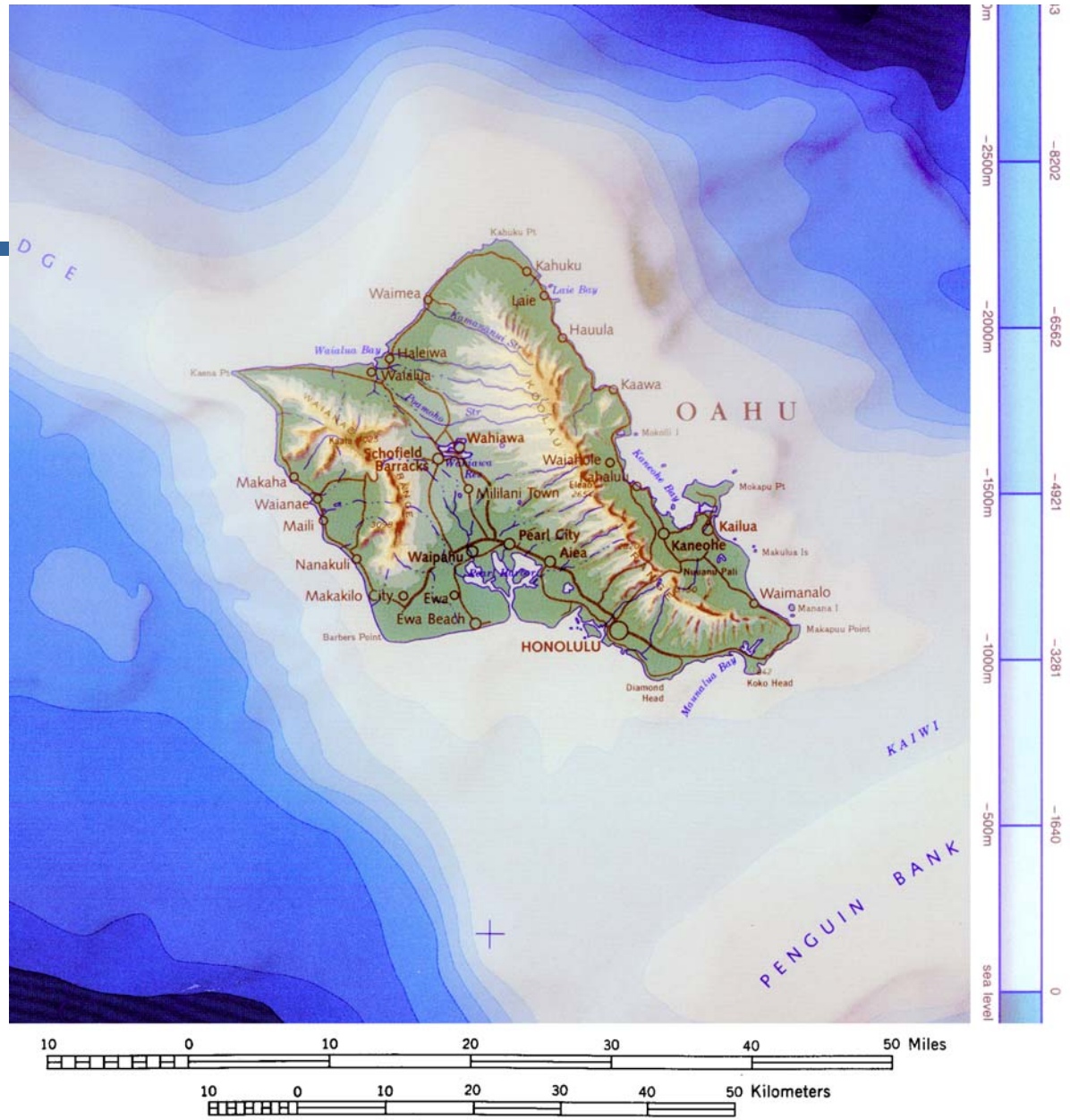


SWAC vs Conventional Design.

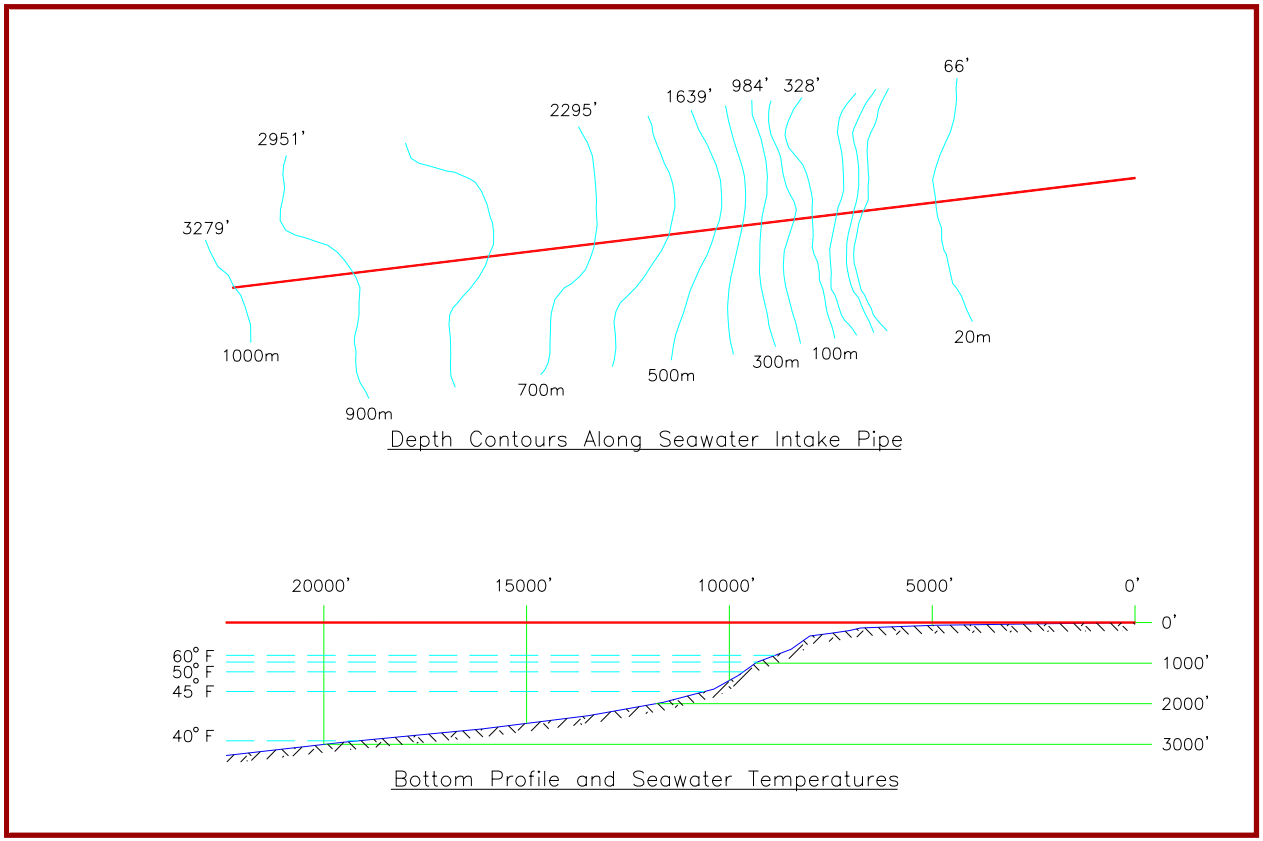
- Minimum Operating Temperature
  - Conventional AC: minimum limited by operating costs.
  - SWAC: minimum limited by source and cost of pipelines.
    - Design to preserve minimum temperature
    - Use boosting chillers, if necessary
- Temperature Differential
  - Conventional AC: Costs proportional to dT.
  - SWAC: Can increase dT at little additional operating cost.
    - Unique design opportunities: open air cooling, etc.

Oahu

- West Coast
- Honolulu
  - Long pipe
  - Large demand

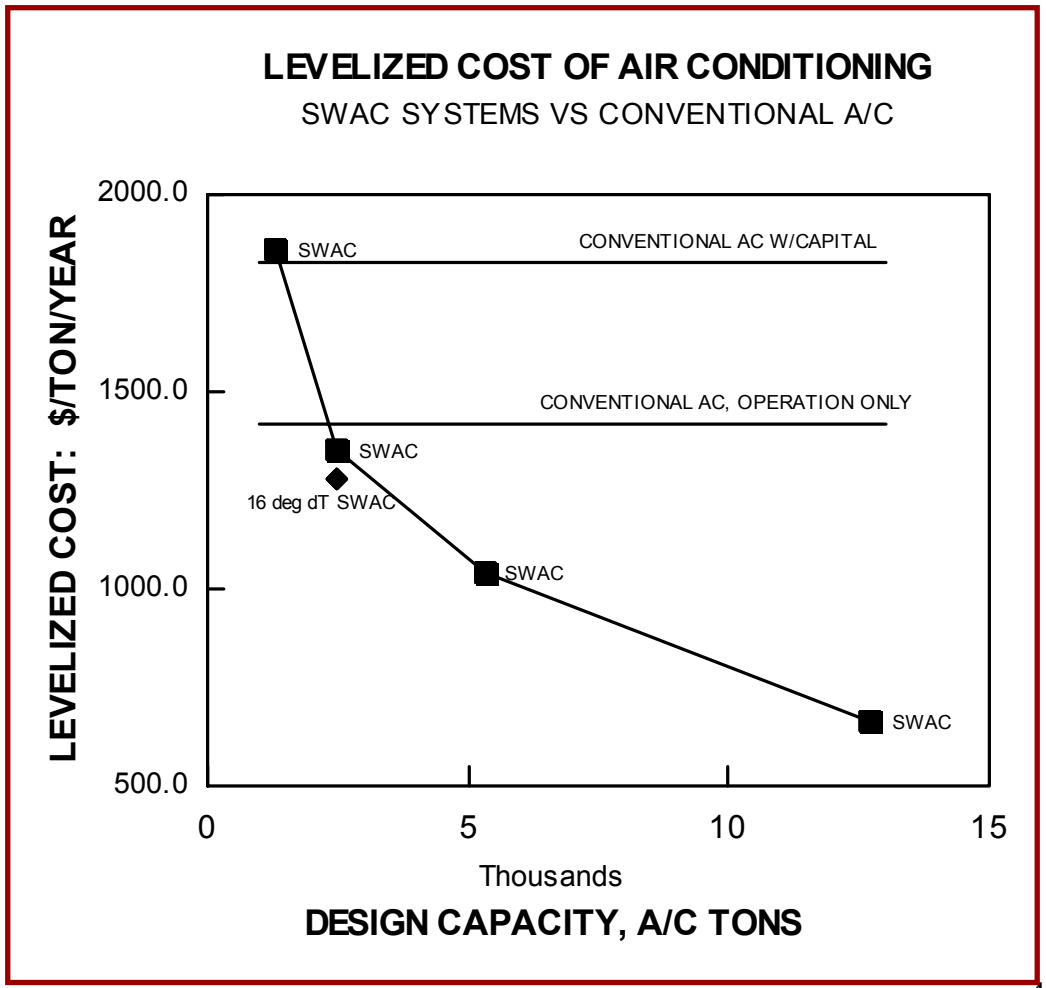


West Beach Bathymetry



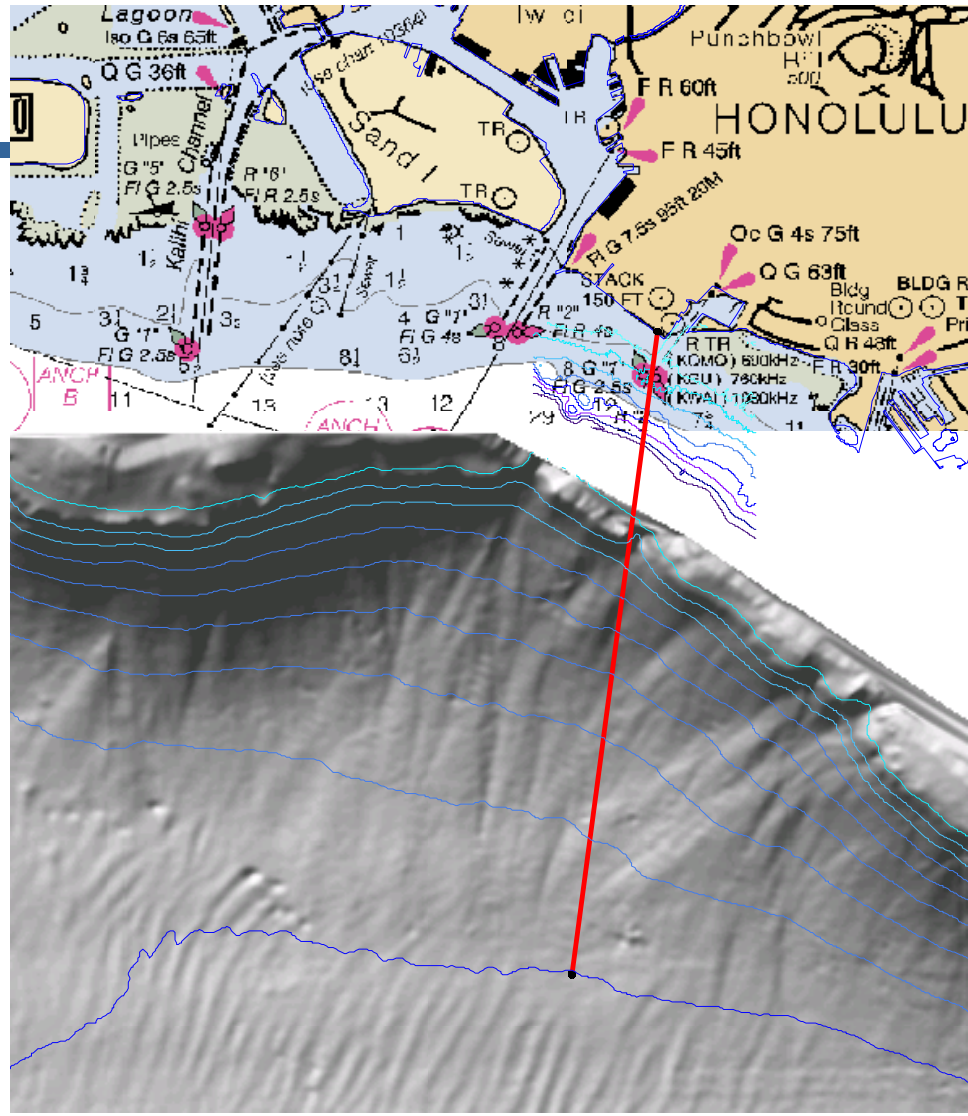
West Beach – Levelized AC Costs

- Clearly Cost Effective
- Size Varied: 12,700 ton to 1,300 ton
- Best Site on Oahu



Kakaako

- New Development
- Large Volume
- Few Landowners
- Pipes slightly longer than Toronto
- Second best site on Oahu



SWAC on Oahu

- A significant and important natural resource
- 75% to 90% energy savings for SWAC
- Very positive environmentally
- Potential Impact on Oahu, ~50,000 tons now
  - save 2% of total power or
  - equal to all solar hot water heaters.
- Widespread use inevitable for Oahu

- Major impact today: An export technology

fini